ICL

System 4
4-70 computer system

Fully-integrated electronics

System 4-70 is a member of the System 4 range, the first computer family in the world in which all processors use fully-integrated circuitry. One monolithic circuit performs the functions of transistors, diodes, capacitors, resistors, and their interconnections. For linking groups of circuits 4-70 uses multi-layer platters with printed circuitry, itself designed by computer. The platters, which combine logical connections and power supply lines, eliminate much of the voluminous rack-wiring that persists in other computer ranges. Fully-integrated circuits bring you these positive advantages:

Reliability. Semi-conductor integrated circuits obviate those weak points inherent in mounting discrete components. And manufacturing the circuits in a controlled environment brings out their full intrinsic reliability.

Cost. They are ideal for mass-production methods and are thus cheaper to make. This is reflected in the remarkable cost/performance value of System 4-70.

Space. Fully-integrated circuits are exceptionally small. Your System 4-70 processor, as a result, is very compact for its power.

Speed. The smallness of fully-integrated circuits makes them intrinsically faster and this has been brilliantly exploited in the outstanding arithmetic speeds of the 4-70 processor.

A computer for the most demanding commercial and scientific applications

System 4-70 meets the most exacting computational requirements of large scale commercial data processing and research. There are four separate sets of registers in the 4-70 scratchpad with an access time of 120 nano-seconds. Each logical aspect has its own independent storage system, eliminating bottlenecks and facilitating a remarkable throughput.
System 4-70 recognises the need for linking different types of computer or to change computers without the heavy burden of reprogramming. 4-70 information and instruction codes are compatible with those of other leading international suppliers. Magnetic tape and discfiles are readily interchangeable.
Powerful data handling and very fast floating-point commands are included in the 4-70 set of 144 instructions. Operations may be carried out on variable length alphanumeric character streams where the amount of calculation on the information being handled is comparatively low, or in binary words where the calculations are more demanding.
Instructions are variable in length and deal compactly with the different needs. They are all implemented by micro-programs held in a *read-only* store and their speed is enhanced by instruction pre-fetching during the execution of the previous instruction.
Below are some examples of 4-70 instruction times. In all cases they include the time for obtaining the instruction from store, fetching the operands from store or register, and placing the results in store or register, according to which is appropriate.

Instruction	**Time** (μs)	**Location**	**Parameters**
Add – Decimal	7·9	Store A + B ➤ A	5 digit numbers
Add – Fixed-point binary	1·0	Registers A + B ➤ A	32 bit numbers
Compare characters	11·4	Store	Two 10 character alphanumeric keys
Multiply – Fixed-point binary	5·4	Registers A × B ➤ A	Two 15 bit numbers
Add – Normalised floating-point	3·3	Registers A + B ➤ A	56 bit precision
Subtract – Un-normalised floating-point	4·3	Indexed store location from register	56 bit precision
Multiply – Floating-point	11·0	Registers A × B ➤ A	56 bit precision
Branch on condition	2·1	Branch address in registers	
Merge patterns ('Or')	1·9	Indexed store to register	Two 30 bit patterns
Load address – Indexed address	1·1	Indexed store location to register	
Shift – Binary	1·8	Register	50 bits shifted 10 places
Pack – Decimal	94·9	Store	Sixteen 5 digit fields from card input form to calculation form
Translate characters	88·0	Store	50 alphanumeric characters from one code to another
Move characters	140·5	Store	250 alphanumeric characters

Exceptional work capacity

System 4-70 can run several full-scale data processing programs concurrently. Multiprogramming is an essential feature of the 4-70. It was developed through ICL's experience of multiprogramming on the Leo 3 range and on KDF 9, and is implemented through a combination of hardware and software. Independently programmed major jobs can be run simply and efficiently at one time because 4-70 has:
a fast interrupt system;
registers located in a scratchpad store (access time 120 nanoseconds);
full store protection for 14 programs at a time:
a program priority control system built into the Executive software.

High information transfer rates
With a data transfer rate of up to 4 million bytes per second, 4-70 eliminates the usual bottleneck in input/output. This extremely high rate is made possible through independently operating multiplexor and selector channels. By operating concurrently with one another and with computing, these channels enable over 500 different peripheral operations to take place at the same time.
Multiplexor channels control up to 16 groups of devices concurrently by interleaving the data received. Three multiplexors can be fitted to the 4-70. Single-channel selectors control only one device at a time although four may be connected. Multi-channel selectors can control eight devices concurrently. The selector channels control and assemble into words all the information for transfer to and from store. Store accesses are thus minimised, and no demands are made on the capacity of the arithmetic unit. A special input/output control enables instructions to be chained together and obeyed by the multiplexor or selector channels independently of the main program.

Maximum input/output capabilities	
Overall transfer rate in bytes a second	4 million
Input/output devices other than remote stations on a transmission network	256 (on selectors) 506 (multiplexors total)
Remote stations	Unlimited
Number of device control units	56
Concurrent multiplexed operations	48
Concurrent selector channels	16
Simultaneous transfer operations	520
Percentage of store access time taken per 1000 bytes/second – multiplexor transfer in progress	0·50%
Percentage of store access time taken per 1000 bytes/second – selector transfer in progress	0·025%
Percentage of arithmetic unit time taken to service information transfers	Nil

Large and varied storage capabilities

Main core store
System 4-70 has a minimum capacity of 65,536 bytes. It can be increased in stages to a maximum of 1,048,576. Four bytes are accessed and regenerated in one store cycle of 0·9 microseconds, but an effective cycle time of 650 nanoseconds is achieved through interleaving. Odd and even addresses are accessed via separate highways so that both are available at the same time. A base and displacement addressing system allows very large stores to be addressed directly.

Scratchpad stores
System 4-70 bases its fast computational and interrupt speeds on a very fast integrated circuit *scratchpad* store with an operation time of less than 250 nanoseconds for four bytes. This is used for arithmetic, base addressing, indexing, floating-point, and interrupt servicing. Independent 250 nanosecond *scratchpad* stores are used for servicing the multichannels.

Micro-program stores
This holds the micro-programming of the individual instructions, and makes it possible to implement the most complex facilities with straightforward, easily maintained circuitry.

Random access backing store
System 4-70 has a variety of random access storage devices which enable it to meet the largest storage requirements. These devices include exchangeable disc units with capacities of 7·25 million bytes, fixed disc stores holding 350 or 700 million bytes, and exchangeable disc stores (EDS 30) of up to 260 million bytes. Many of these devices can be linked at one time to System 4-70 through the selector channels. The total on-line capacity is vast.

Magnetic tape storage
System 4-70 can at the same time handle both seven- and nine-track magnetic tape units with speeds of up to 200,000 bytes a second, which is the equivalent of 400,000 decimal digits a second. This flexibility means that the 4-70 is compatible simultaneously with existing seven-track tape systems and the latest nine-track systems. Duplex device control units make it possible to drive one magnetic tape unit through two separate channels as convenience dictates. A linked pair of magnetic tape device control units can simultaneously read or write information from or to any two of 16 tape units.

Comprehensive software

To give maximum utilisation of a System 4-70 installation, its outstanding technology has been matched by comprehensive software and operating systems. The operating systems cover all 4-70 configurations and provide flexible modular program facilities to run each job in the most efficient and economical manner. It will be possible to develop and run installation programs and employ the vast computing potential made available by multiprogramming, more quickly than ever before.
System 4-70 provides both the commercial and scientific user with all the languages most widely employed today. The initial complement of COBOL, FORTRAN, ALGOL, APT, and CLEO will be supplemented by other languages as they gain international acceptance. These efficient programming facilities enable work to be programmed and mounted quicker, and programs to be transferred easily from existing equipment.

Modular software packages
Software complements for small configurations are subsets of those for larger configurations, and can be gradually built up as the configuration is expanded. This ensures not only that the right software is available, but also that storage and peripheral requirements for a particular user are not excessive.

Easy program development
Programs may be written in a variety of source languages and tested in small sections or in larger combinations of source text. Independently compiled sections can be combined to form a complete binary program ready for production use.

System 4-70 software facilities include:

Usercode assembly system	A convenient machine-oriented assembly system using mnemonic instructions with symbolic addressing and input/output macros
Executive	Undertakes the management of the complete system including such functions as job control, store allocation, input/output control, multiprogramming, and operator communication
Program trials system	A program development facility providing, by means of parameters, a variety of testing and diagnostic aids capable of being invoked by the user at specified points in a program
Media conversion generator	To produce programs to take input data from any medium and output the data to any medium in a format specified by the user
Communication control routine	A comprehensive control routine for communication lines, with facilities for error detection and re-transmission
System library maintenance	To create, amend, operate, and edit program libraries stored on magnetic tape and other media
Library subroutines	Subroutines to perform basic programming functions which may be incorporated in the machine code program during compilation
CLEO compiler	Implementation of the highly successful language introduced on Leo 3
COBOL compiler	A full COBOL implementation including sort, report writer, and random access input/output
ALGOL compiler	Implementation of ALGOL 60 including all those facilities provided with KDF 9
FORTRAN compiler	A full implementation of FORTRAN IV including extended arithmetic and data types

APT compiler	A compiler for the numerical control of automatically programmed machine tools
CSL simulation language compiler	For the construction of mathematical models to solve scientific and business problems
File control routines	Provide complete control over input/output operations including multiple buffering areas, restart check points, and multi-file control
Sort program generator	Generates either generalised or special programs for sorting or merging
Report program generator	Incorporates a simple language providing facilities for writing programs to produce reports
PERT	Two packages are provided to analyse PERT networks – Time, and Resource Allocation
Linear programming (Transportation)	A program suite to solve transportation problems, yielding solutions in source or destination order. New problems can be started from existing solutions
Linear programming (Simplex)	A program suite to check data, calculate solutions, and print answers. The solution consists of values of basic variables, objective function, and shadow costs on run-basis variables
Matrix scheme	Facilities for manipulating matrices, matrix arithmetic, automatic storage, and for handling diagonal and symmetric matrices

A computer for the largest and most complex jobs

Commerce and government
As a very large general purpose computer, System 4-70 will handle a wide variety of high volume clerical work, running up to 14 programs at a time. It effectively acts as several large computers, working back to back, with all the benefits of shared storage and facilities. The very large number of peripheral devices that can run concurrently on System 4-70, and the even larger number that are accessible at any one time, ensure that a multiprogrammed system will never be short of input/output capacity. Also, the very large core store that is available at reasonable cost makes it possible to store a number of very large programs and their related data without constraints.
System 4-70 is ideal for large scale work. It is an excellent tool too for the management sciences, for design automation planning, and the forecasting and engineering calculations which most large organisations have as a secondary load.

Science and research
System 4-70 is a very powerful scientific research tool. It will hold a large variety of programs, complete and under development, in a random access store. Powerful software for handling such a program bank has already been shown in operation on the KDF 9 computers.
For the University which requires a computer that will cope equally well with research in depth, training in numerical science, and the administrative work of the community, System 4-70 offers the wide variety of facilities, hardware and software, that is needed.

Satellite applications
Operated as the controller of a network of interconnected computers, System 4-70 will pass information and allocate tasks to subservient machines. By multiprogramming, it can itself at the same time shoulder the heaviest tasks in the network of scientific and management science computation, and display the results direct to management. Where it is required to off-load data reduction or printing tasks, a smaller member of the family, the 4-40, can provide all that is necessary to take the load on-line or off-line and on-site or remotely.

Communication systems
4-70 can be used as the centre of a data transmission network, controlling remote stations fitted with such devices as enquiry stations and automatic data capturing devices. System 4-70 offers immediate response to enquiries, however complex the calculations they require. A very considerable number and variety of remote devices can be handled at any one time.

Left: The North Western Electricity Board's System 4-70 in Manchester. The machine uses extensive magnetic disc storage and is the central computer in a multi-access system involving 70 remote terminals in showrooms and district offices.

Input/output devices

Peripheral equipment covering the full range of input/output, storage, and communication requirements is available with System 4-70. There is a standard interface. Any System 4 peripheral device can be used with any System 4 processor and peripherals can be added on site by simply plugging in.

Paper tape units	
Reader	1,500 characters a second
Punch	150 characters a second
Card units	
Readers	800 or 1,435 cards a minute
Punches	100 or 300 cards a minute
Line printers	
Medium-speed model	750 lines a minute (1,500 lines a minute with optional double numeric barrel)
High-speed model	1,350 lines a minute (2,700 lines a minute with optional double numeric barrel)
Magnetic tape units	
Seven-track	Up to 60,000 characters a second
Nine-track	30,000, 60,000, 120,000 or 200,000 bytes a second
Random access devices	
Exchangeable disc store	Capacity 7·25 million bytes
Fixed disc store	Capacity 350 or 700 million bytes
Exchangeable disc store (EDS 30)	Total capacity 260 million bytes
Magnetic drum	Capacity 2·2 million bytes
Digital plotters	200 or 300 steps a second 0·005 inches, 0·01 inches or 0·1 millimetres step size
Universal document reader	300 (8″) documents a minute, or 150 (8″ or larger) documents a minute
Communications equipment	Equipment for linking processors to other processors, enquiry stations, and data transmission lines.

Right: One of the National Giro centre's three System 4-70's. Twenty-two magnetic tape units and three exchangeable disc stores provide backing storage.

The right is reserved to change this information without notice.

ICL

International Computers Limited

Head Office
ICL House
Putney
London SW15

Sales Headquarters:
Bridge House, Putney Bridge, London SW6 (01-788 7272)

Area sales offices

Aberdeen 14 Bon Accord Crescent, AB1 2DE (0224-51371/2)
Beckenham 205/213 High Street, BR3 1DS (01-650 7231 or 8131)
Provident House, 6/20 Burrell Row, BR3 1DS (01-650 7231 or 8131)
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Birmingham, 5 Bridge House, 121 Smallbrook (021-643 5033)
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5/11 Holborn, EC1 (01-242 3311)
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Newcastle-upon-Tyne Crestina House, Archbold Terrace, NE2 1DT (0632-810301/6)
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Norwich Castle House, 21 Davey Place, NOR 38E (0603-26132/3/4)
Nottingham Bridgford House, Trent Bridge, NG2 5FM (0602 82011)
Oxford Mayfield House, 256 Banbury Road, Summertown, OX2 7DJ (0092 57364/5)
Preston Crystal House, Birley Street, PR1 2DQ (0772 57927)
Sheffield St. James' House, Vicar Lane, S1 1LS (0742-27186/7/8/9)
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Wilmslow St. Anne's House, Alderley Road (0996-4 27461)
Wolverhampton Clarence House, Darlington Street (0902 27576)

Dataset Limited

Head Office Arena House, Broadway, Letchworth, Hertfordshire(0462-6 4211)
Area Sales Offices *Southern Region*
84 Newman Street, London W1 (01-637 7211)
Northern Region
Television House, 10/12 Mount Street, Manchester M2 5WS (061-832 8021)
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International Computing Services Limited

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Birmingham, 5 Bridge House, 121 Smallbrook, Ringway (021-643 9061)
Bristol 36/38 Baldwin Street, BS1 1NR (0272 21406)
Cork Monument Buildings, Grand Parade (Cork 20435)
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Dividend service bureau

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User programming service

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O.E.M. sales

Headquarters: Cavendish Road, Stevenage, Hertfordshire (0438 3361)

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1/2 Factory, Icknield Way, Letchworth (0462-6 2326)

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